



LED Tank Top

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TOOLS:

- [Fabric marker \(1\)](#)
- [Multimeter \(1\)](#)
- [Scissors \(1\)](#)
- [Sew No More \(1\)](#)
- [Sewing machine \(1\)](#)
- [Sewing needle \(1\)](#)
- [Soldering iron \(1\)](#)
- [T-square \(1\)](#)



PARTS:

- [Thread \(1\)](#)
- [LED \(1\)](#)
- [Liquid stitch \(1\)](#)
- [AVRmega15 microcontroller \(1\)](#)
- [DC power supply \(1\)](#)
- [Serial adapter \(1\)](#)
- [Battery holder \(1\)](#)
- [On/off switch \(1\)](#)
- [AVR programmer \(1\)](#)
- [Lead-free solder \(1\)](#)
- [Crimping beads \(1\)](#)
[about twice as many as LEDs](#)
- [Garment \(1\)](#)
[or a piece of fabric and a pattern to make your own](#)

SUMMARY

I built this shirt to experiment with wearable computing and electronic textile technology and

realized along the way that the basic materials were actually quite easy to work with and there was lots of room for creativity and innovation at all levels, so I was inspired to write up this do-it-yourself guide. Everyone should be playing with this stuff! It's great fun for geeks and divas — build yourself a sparkly fashion accessory and program it with the Game of Life or other hacker animations. You're guaranteed to turn heads whenever you're out on the town.

Step 1 — Gather your materials.

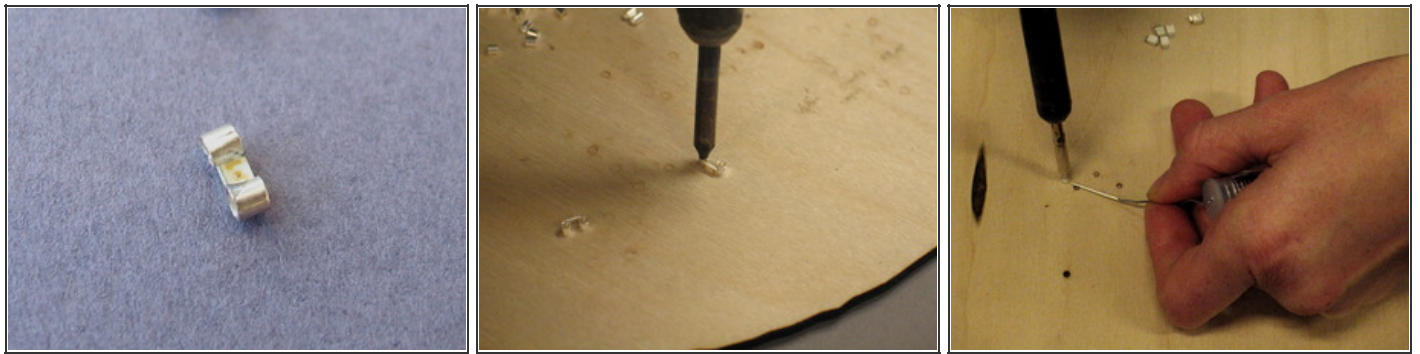


- Here's an overview of all the materials and tools you'll need.
- Clear a work space and stay organized.

Step 2 — Design your display.

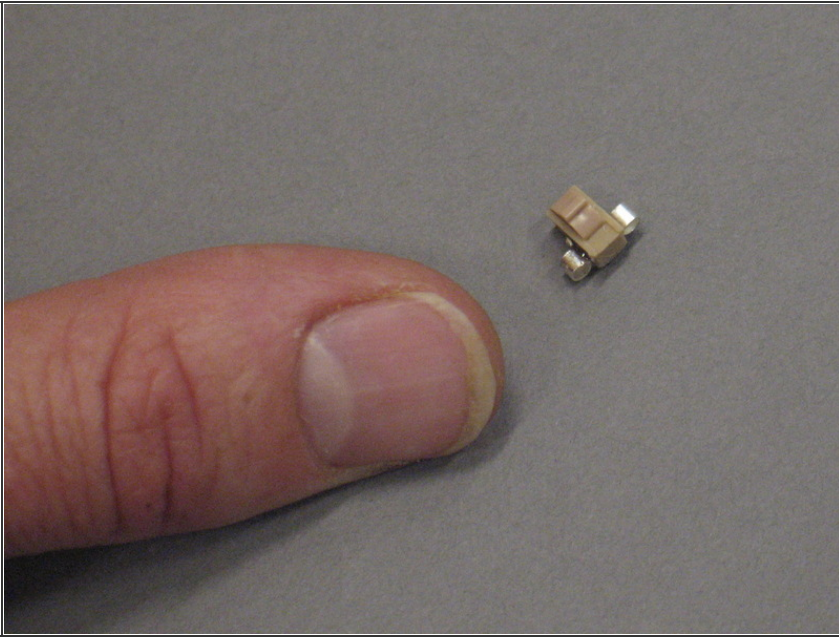
- Decide on the number of LEDs you want and their general placement. This will depend on the garment you chose as well as how you'd like the display to look.
- I decided to sew a simple tank top, and I chose to place the LEDs evenly across my tank top every 2". Since my tank top is approximately 28" around and 12" tall, I needed 84 LEDs.

Step 3 — Make sequins with your beads and LEDs.



- Get out the crimping beads and surface mount LEDs.
- Using a soldering iron with a very clean tip, place the tip of the iron into a bead. Melt some solder onto the outside of the bead. With the soldering iron, drag the bead up to the LED.
- When the melted solder touches the LED's contact, the bead will adhere to the LED. Lift the soldering iron out of the bead.
- At this stage, you may want to take some measures to distinguish the cathode lead (-) from the anode lead (+) of each LED.
- The cathode end is often marked with a green line on the front or back of the surface mount package. To distinguish the two, you can solder a brass crimping bead to the cathode lead and a silver bead to the anode lead for each LED. 
- TIP: If your soldering iron tip is dirty, it will stick to the bead and make the job very difficult. If this is happening, you should clean or replace your tip. Once you get the hang of it, this should go pretty fast. You should be able to solder 100 LEDs within an hour. 

Step 4



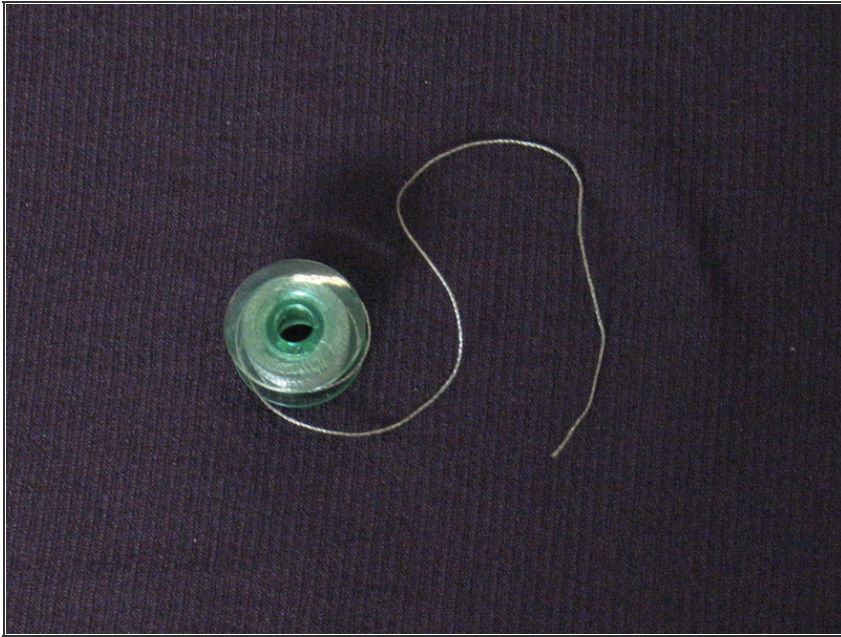
- In a similar way, solder beads to the appropriate leads for your battery and switch, so that they can also be sewn on.
- This is the switch sequin.

Step 5 — Sew your LED matrix.



- With a marking pen, mark the lines for your LED pattern on the garment.
- Also, mark where you want your microcontroller (IC socket) and power supply to be.
- You want a grid of conductive traces where the vertical traces do not touch the horizontal ones. A simple way to do this is to put one trace on one side of the fabric and the other trace on the flip side of the fabric, utilizing the fabric as a natural insulator. The lines for the vertical traces should be on one side of your garment, and the lines for the horizontal traces should be on the other.
- I marked both sets of lines on both sides of my tank top to make sure my lines were well placed. Use a T-square to get good right angles and straight lines.



Step 6

- Make a bobbin of silver-coated thread for your sewing machine, and put it in the machine. Use a spool of ordinary thread for the top thread.
- Using silver-coated thread in the bobbin of a sewing machine will allow you to sew conductive horizontal traces on one side of your garment and conductive vertical traces on the other side. As you sew, the bobbin thread will remain on the underside of the fabric you are sewing.



Step 7

- Sew one trial row-column crossing, and use the multimeter to make sure your threads are being sufficiently insulated by the fabric. If your fabric is too thin, the bobbin thread may be pulled through the fabric, and your crossing traces may short out.
- If there is contact at your intersections, you will need to take action to correct this. As you are sewing out the traces, you should stop the sewing machine just before each intersection, and, without breaking the threads, move your fabric past the intersection and resume sewing. This will ensure that the silver-coated thread stays on the proper side of the fabric at each crossing.

Step 8

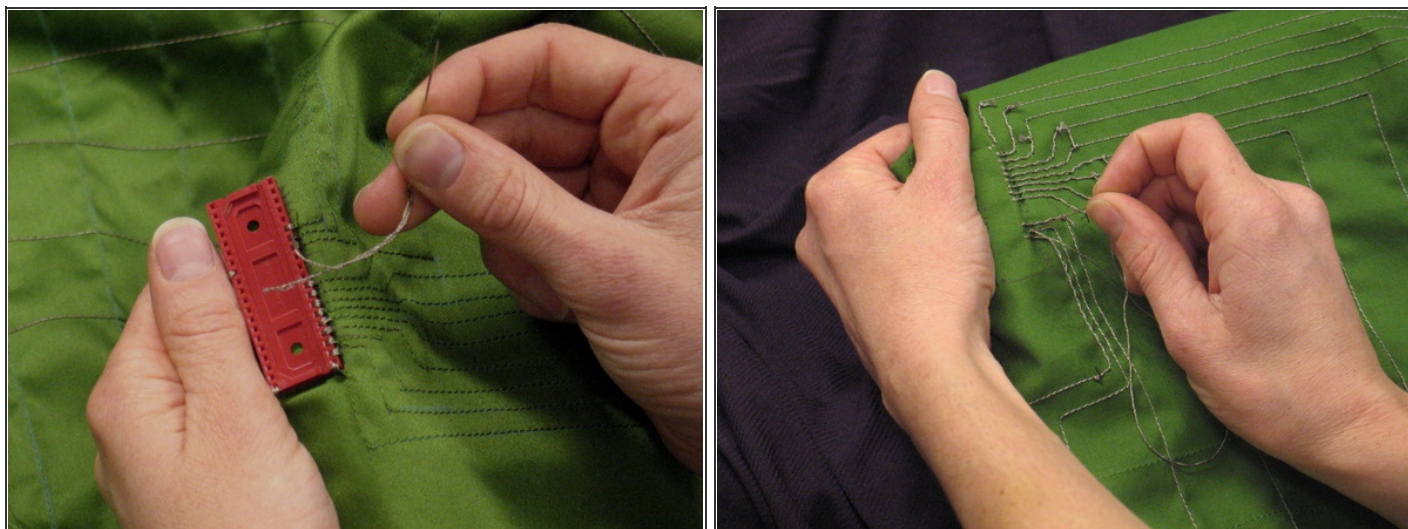


- Sew out your vertical traces. Flip your garment over and sew out your horizontal traces.
- Sew one trial row-column crossing, and use the multimeter to make sure your threads are being sufficiently insulated by the fabric. If your fabric is too thin, the bobbin thread may be pulled through the fabric, and your crossing traces may short out.
- You should stop your pattern stitches a few inches from the IC socket to leave room for the knots you will make when sewing the socket on by hand.
- Here are the top and bottom views of my partially assembled tank top after I sewed on my traces.

Step 9 — Prepare and sew on the IC socket.

- Before you start sewing threads onto the IC socket, you should familiarize yourself with the pins of the microcontroller. Here's the pin layout diagram for the ATmega16 chip.
- All the pins labeled PA0-PA7, PB0-PB7, PC0-PC7, and PD0-PD7 are general-purpose input/output pins that can be used to power LEDs and the like. See my sample code and header files to see how to reference and control individual pins with your code.

Step 10



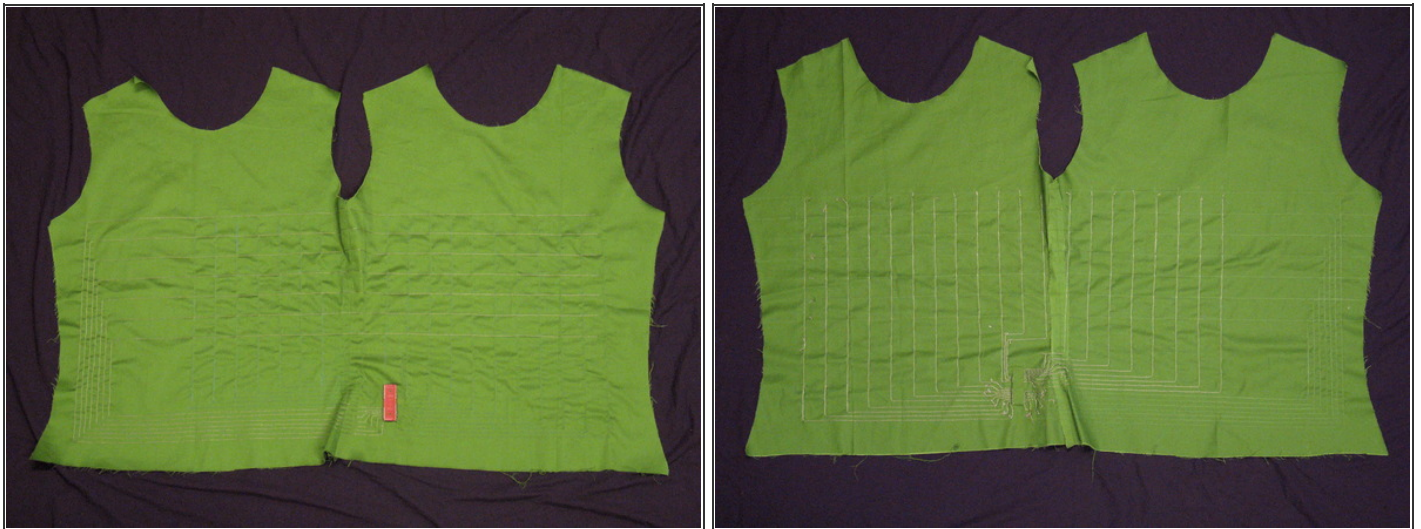
- Trim the pins off the bottom of the socket and pull off any tape or other material blocking the holes. If necessary, drill out the holes so that a needle can pass through them. Position the socket where you want it on your garment and stitch it in place with silver-coated thread, sewing traces from each microcontroller socket to the pattern traces you sewed.
- You want to make sure that the silver-coated thread makes contact with each socket hole, but also be careful that no two threads cross. This is a delicate job that requires some patience, but if you're used to doing soldering or any other meticulous work, it should be no problem. 

Step 11



- Make sure that you tie your knots where there is ample room for them (away from the socket) and where they're less likely to cause shorts with neighboring traces. Coat each knot with fabric glue. This will keep knots from fraying and coming untied.

Step 12 — What is a short?



- A short or “short circuit” occurs when the positive terminal of a power supply is connected directly to the negative terminal of a power supply. On your shirt, if two neighboring traces are touching while one of them is high (positive) and the other is low (negative), a short circuit is created. This kind of short circuit will prevent your LEDs from lighting up and is likely to cause your microcontroller to overheat and eventually die. Short circuits in more high-powered applications can cause fires and explosions.

Step 13



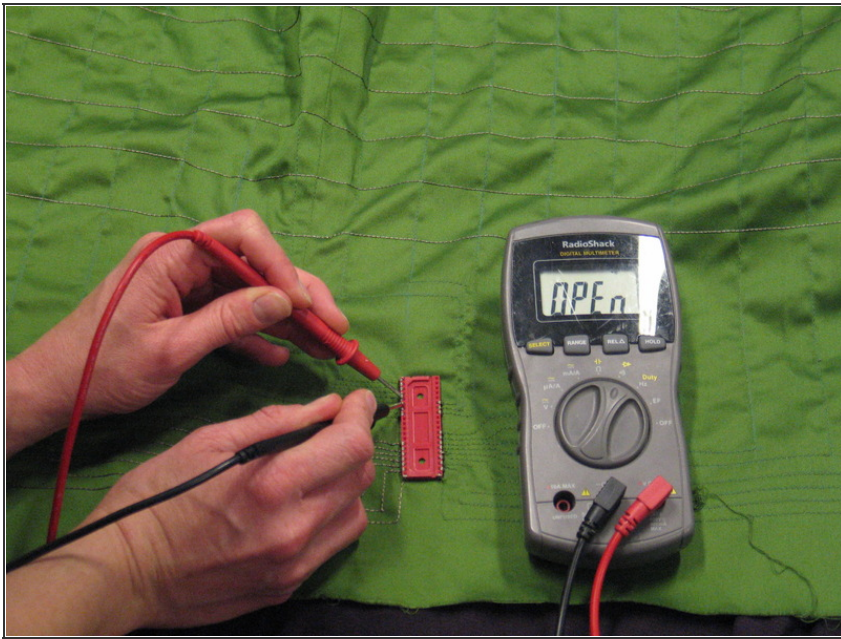
- Attach the cathode end of each LED to a row, and the anode end of each LED to a column (or vice versa). If you did not take steps during the soldering phase to differentiate the cathode from anode leads, you will have to make the distinction now.
- The cathode end of the LED is often marked with a green line on the front or back of the surface mount package. If you are able to find this marking despite your soldering, you can use it. Otherwise, learn to distinguish the direction from the appearance of the face of the LED. Test one by running a current through it for reference. Be careful to use a voltage and current appropriate for your LED.

Step 14



- While sewing, take care to make good connections between your thread and each bead, looping the thread through each bead several times, as shown here.
- The fastest way to sew is to stitch each row and column continuously, not stopping to tie off the thread for each LED. In other words, sew in the cathode end of one LED, and sew down your row to the next LED cathode without cutting your thread. 
- However, this makes replacing badly sewn or broken LEDs harder, since you'll have to cut the continuous thread and tie the ends off in the event of a problem. Alternatively, you can sew each LED on individually. This will make repairs easier, but your sewing will take much longer. I chose the first option for faster sewing, but I did have to replace a few LEDs. 

Step 15 — Test your circuit.



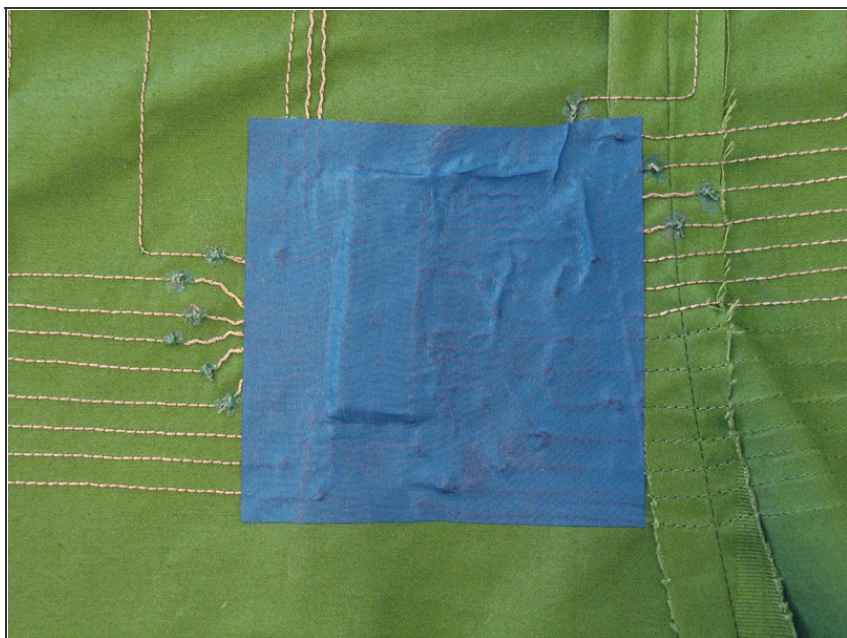
- Using a multimeter, make sure none of your traces are shorting out with one another, and all of them are leading to the appropriate LED rows and columns. Silver-coated thread tends to fray and give off small “hairs.”
- Make sure there are no miniscule conducting hairs interfering with any of your traces.

Step 16



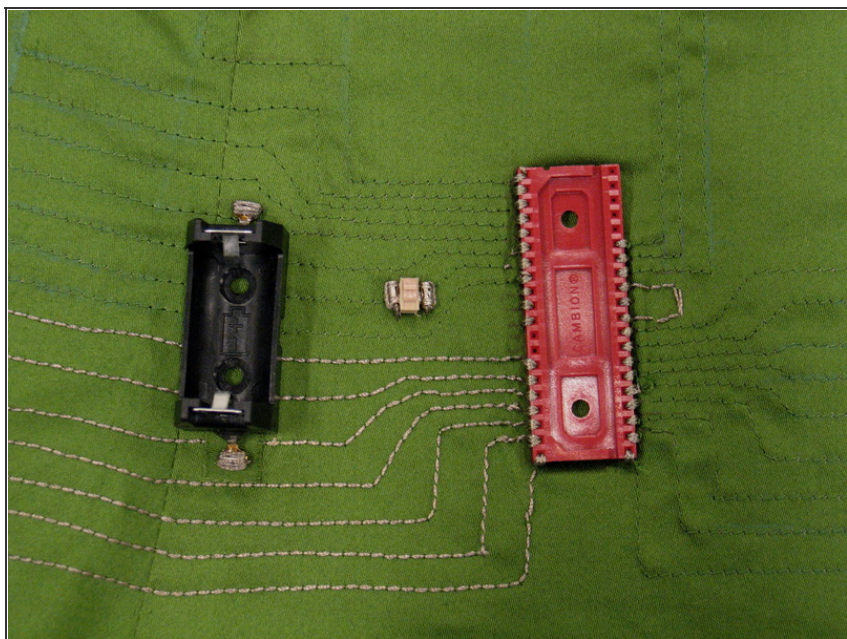
- You may also want to make sure your LED pattern is working properly by attaching the leads of your power supply to the rows and columns of your pattern in turn. Look at the specifications that came with your LEDs if you're not sure what power supply to use or you may fry all of your LEDs! My multimeter (in beep mode) doubles as a low-current power supply, illuminating an LED when its leads are attached to the right threads.

Step 17



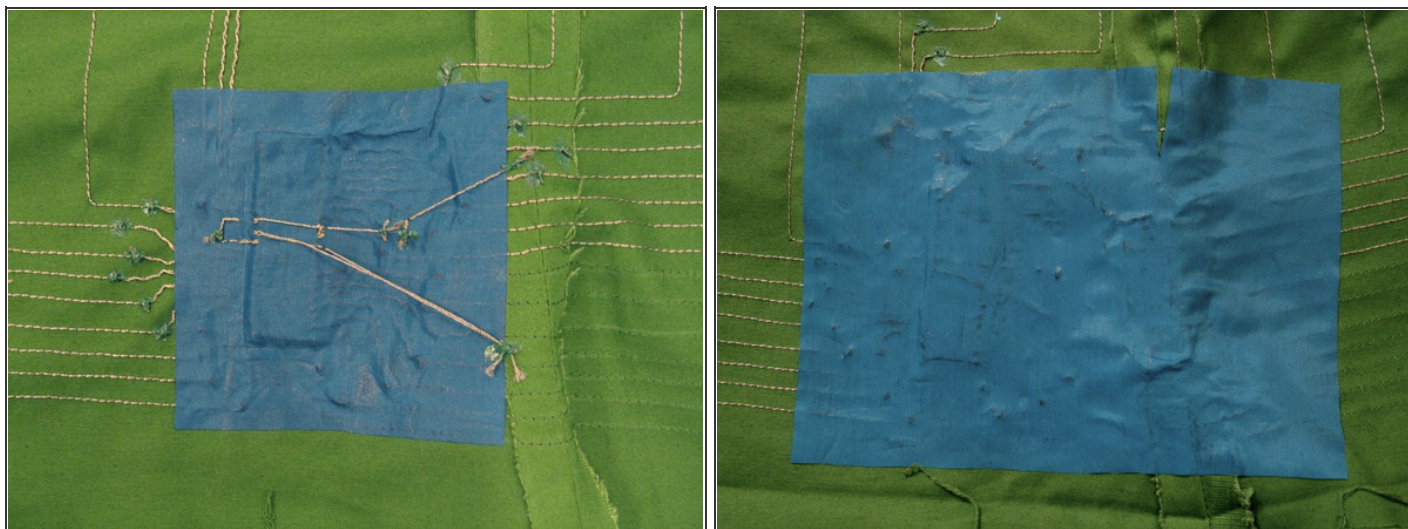
- Once you've done some thorough testing, glue an insulating backing onto the traces you sewed for your IC socket, so that your power supply will be easy to attach and these traces will remain in place without fraying with wear.

Step 18 — Attach the power supply and switch.



- Sew the switch and power supply to the garment.

Step 19



- Glue an insulating backing over your power supply and switch traces so that you will not accidentally turn on your display.
- Here is the inside view of my tank top after I sewed on the power supply. Notice the insulating backing that was applied prior to sewing.

Step 20 — Program the controller.



- Download the code for the "Game of Life" along with software to compile the program on your PC and connect to and download the program to the AVR microcontroller.
- A British mathematician named John Horton Conway invented the "Game of Life" in 1970 as a way to simulate cell-based birth, reproduction, and death based on simple rules. Wikipedia has [an excellent article about The Game of Life](#).
- Follow the instructions for installing the software and setting it up to program the controller at [LED Tank Top Code Install](#).



This project first appeared in [CRAFT Volume 01](#).

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